

## CLAIMS

What is claimed is:

1. A network device, comprising:

5 a virtual router subsystem including a plurality of virtual routers, each virtual router associated with a corresponding different virtual private routed network (VPRN) and employing generic interface identifiers to identify associated interfaces at which routing traffic for the associated VPRN is received and transmitted;

a plurality of physical interfaces coupled to physical network links connecting the network device to other network devices; and

a virtual interface subsystem operative to couple the virtual router subsystem to the physical interfaces, the virtual interface subsystem including a plurality of virtual interfaces, the virtual interfaces being organized into linked sets, each linked set being operative to associate a generic interface identifier of a given virtual router with a corresponding physical interface coupled to a network link connecting the network device to another network device serving the same VPRN.

2. A network device according to claim 1, wherein the virtual interfaces included in the virtual interface subsystem include  
25 channel virtual interfaces and media virtual interfaces, each channel virtual interface being operative to associate a generic interface identifier of the virtual router subsystem with a virtual channel defined in the network device, and each media virtual interface being operative to associate a virtual channel  
30 with a corresponding physical interface and physical channel defined on the associated physical network link.

3. A network device according to claim 2, wherein the virtual interfaces included in the virtual interface subsystem further include automatic protection switching virtual interfaces, each automatic protection switching virtual interface being operative to associate a virtual channel with two media virtual interfaces serving as alternative interfaces for sending or receiving routing traffic.

4. A network device according to claim 3, wherein the physical network links connected to other network devices include access links and backbone links, and wherein the sets of virtual interfaces include first and second sets, the first set including only a channel virtual interface and a media interface and being associated with an access link, and the second set including a channel virtual interface, an automatic protection switching virtual interface, and a media interface and being associated with a backbone link.

5. A network device according to claim 2, wherein the channel virtual interfaces are channel virtual interfaces of a first type, and further including channel virtual interfaces of a second type, each second-type virtual interface being operative to associate a label of a label-switched path via which routing traffic can be sent or received with a corresponding virtual channel, and wherein the types of virtual interfaces included in the virtual interface subsystem further include label virtual interfaces, each label virtual interface being operative to associate a generic interface identifier of the virtual router subsystem with a label for such a label-switched path.

6. A network device according to claim 5, wherein the physical network links connected to other network devices include access links and backbone links, and wherein the sets of virtual

interfaces include first and second sets, the first set including only a channel virtual interface and a media interface and being associated with an access link, and the second set including a label virtual interface, a channel virtual interface, and a media interface and being associated with a backbone link.

7. A network device according to claim 5, wherein the label virtual interfaces are of a first type associated with inner label-switched paths, and wherein the virtual interfaces further include label virtual interfaces of a second type associated with outer label-switched paths, each outer label switched path logically including multiple inner label-switched paths.

8. A network device according to claim 1, wherein the types of virtual interfaces included in the virtual interface subsystem include label virtual interfaces, each label virtual interface being operative to associate a generic interface identifier of the virtual router subsystem with a label for a label-switched path via which routing traffic can be sent or received.

9. A network device according to claim 8, wherein the label virtual interfaces include label virtual interfaces of a first type associated with inner label-switched paths, and of a second type associated with outer label-switched paths, each outer label switched path logically including multiple inner label-switched paths.

10. A network device according to claim 1, wherein the types of virtual interfaces included in the virtual interface subsystem include channel virtual interfaces, media virtual interfaces, inner label virtual interfaces, and outer label virtual interfaces, each inner label virtual interface being operative to associate a generic interface identifier of the virtual router

subsystem with an inner label-switched path via which routing traffic is sent or received, each outer label virtual interface associating multiple inner label-switched paths with an outer label-switched path in which the associated inner label-switched paths are logically included, each channel virtual interface being operative to associate an outer label-switched path with a virtual channel defined in the network device, and each media virtual interface being operative to associate a virtual channel with a corresponding physical interface and physical channel defined on an associated physical network link.

11. A network device according to claim 10, wherein one type of set of linked virtual interfaces includes an inner label virtual interface, an outer label virtual interface, a channel virtual interface, and a media virtual interface.

12. A network device according to claim 10, wherein one type of set of linked virtual interfaces includes an inner label virtual interface, two outer label virtual interfaces, two channel virtual interfaces, and two media virtual interfaces, one of each of the outer label, channel and media virtual interfaces being linked to form a first interface via which routing packets can be sent or received, and the other of each of the outer label, channel and media virtual interfaces being linked to form a second, redundant interface via which routing packets can be sent or received.

13. A network device according to claim 10, wherein one type of set of linked virtual interfaces includes two inner label virtual interfaces, two outer label virtual interfaces, two channel virtual interfaces, and two media virtual interfaces, one of each of the inner label, outer label, channel and media virtual interfaces being linked to form a first interface via which routing packets can be sent or received, and the other of each of

the inner label, outer label, channel and media virtual interfaces being linked to form a second, interface via which routing packets can be sent or received, the first and second interfaces serving as both a redundant pair of interfaces and as a load balanced pair of interfaces for routing packets from two distinct virtual routers in the virtual router subsystem.

14. A method of operating a network device having a plurality of physical interfaces coupled to corresponding physical network links connecting the network device to other network devices, comprising:

operating a plurality of virtual routers, each virtual router being associated with a corresponding different virtual private routed network (VPRN) and employing generic interface identifiers to identify associated interfaces at which routing traffic for the associated VPRN is received and transmitted;

maintaining a plurality of virtual interfaces, the virtual interfaces being organized into linked sets each operative to associate a generic identifier used by a given virtual router with a corresponding physical interface to another network device serving the same VPRN;

for routing protocol messages transmitted by a given virtual router at a given interface, obtaining physical interface information from the linked set of virtual interfaces associated with the generic interface identifier of the interface, the physical interface information identifying a corresponding physical interface of the network device via which the routing protocol messages are to be transmitted, and transmitting the routing protocol messages on the network link coupled to the identified physical interface.

15. A method according to claim 14, wherein the virtual interfaces include channel virtual interfaces and media virtual interfaces,

each channel virtual interface being operative to associate a generic interface identifier of a corresponding virtual router with a virtual channel defined in the network device, and each media virtual interface being operative to associate a virtual channel with a corresponding physical interface and physical channel defined on the associated physical network link.

16. A method according to claim 15, wherein the virtual interfaces further include automatic protection switching virtual interfaces, each automatic protection switching virtual interface being operative to associate a virtual channel with two media virtual interfaces serving as alternative interfaces for sending or receiving routing traffic.

17. A method according to claim 16, wherein the physical network links connected to other network devices include access links and backbone links, and wherein the sets of virtual interfaces include first and second sets, the first set including only a channel virtual interface and a media interface and being associated with an access link, and the second set including a channel virtual interface, an automatic protection switching virtual interface, and a media interface and being associated with a backbone link.

18. A method according to claim 15, wherein the channel virtual interfaces are channel virtual interfaces of a first type, and further including channel virtual interfaces of a second type, each second-type virtual interface being operative to associate a label of a label-switched path via which routing traffic can be sent or received with a corresponding virtual channel, and wherein the types of virtual interfaces further include label virtual interfaces, each label virtual interface being operative to associate a generic interface identifier of a corresponding virtual router with a label for such a label-switched path.

19. A method according to claim 18, wherein the physical network links connected to other network devices include access links and backbone links, and wherein the sets of virtual interfaces include first and second sets, the first set including only a channel virtual interface and a media interface and being associated with an access link, and the second set including a label virtual interface, a channel virtual interface, and a media interface and being associated with a backbone link.

20. A method according to claim 18, wherein the label virtual interfaces are of a first type associated with inner label-switched paths, and wherein the virtual interfaces further include label virtual interfaces of a second type associated with outer label-switched paths, each outer label switched path logically including multiple inner label-switched paths.

21. A method according to claim 14, wherein the types of virtual interfaces include label virtual interfaces, each label virtual interface being operative to associate a generic interface identifier of a corresponding virtual router with a label for a label-switched path via which routing traffic can be sent or received.

22. A method according to claim 21, wherein the label virtual interfaces include label virtual interfaces of a first type associated with inner label-switched paths, and of a second type associated with outer label-switched paths, each outer label switched path logically including multiple inner label-switched paths.

23. A method according to claim 14, wherein the types of virtual interfaces include channel virtual interfaces, media virtual

interfaces, inner label virtual interfaces, and outer label virtual interfaces, each inner label virtual interface being operative to associate a generic interface identifier of a corresponding virtual router with an inner label-switched path via which routing traffic is sent or received, each outer label virtual interface associating multiple inner label-switched paths with an outer label-switched path in which the associated inner label-switched paths are logically included, each channel virtual interface being operative to associate an outer label-switched path with a virtual channel defined in the network device, and each media virtual interface being operative to associate a virtual channel with a corresponding physical interface and physical channel defined on an associated physical network link.

24. A method according to claim 23, wherein one type of set of linked virtual interfaces includes an inner label virtual interface, an outer label virtual interface, a channel virtual interface, and a media virtual interface.

25. A method according to claim 23, wherein one type of set of linked virtual interfaces includes an inner label virtual interface, two outer label virtual interfaces, two channel virtual interfaces, and two media virtual interfaces, one of each of the outer label, channel and media virtual interfaces being linked to form a first interface via which routing packets can be sent or received, and the other of each of the outer label, channel and media virtual interfaces being linked to form a second, redundant interface via which routing packets can be sent or received.

26. A method according to claim 23, wherein one type of set of linked virtual interfaces includes two inner label virtual interfaces, two outer label virtual interfaces, two channel virtual interfaces, and two media virtual interfaces, one of each



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the inner label, outer label, channel and media virtual interfaces  
5 being linked to form a second, interface via which routing packets  
can be sent or received, the first and second interfaces serving  
as both a redundant pair of interfaces and as a load balanced pair  
of interfaces for routing packets from two distinct virtual  
routers.

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